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We Claim:

1. A parallel, combinatorial method for the discovery and optimization of novel catalysts for chemical transformations, comprising:
  - 5 (a) chemically synthesizing a variegated library of potential catalysts; and
  - (b) screening the library of potential catalysts to identify those members that catalyze the transformation of interest.
2. The method of claim 1, wherein the potential catalysts comprise a natural or unnatural amino acid.
- 10 3. The method of claim 1, wherein the library comprises a catalyst that catalyzes a stereoselective reaction.
4. The method of claim 1, wherein the library comprises a catalyst that catalyzes a chemoselective and/or regioselective reaction.
5. The method of claim 1, wherein the potential catalysts comprise a cyclic moiety  
15 selected from the group consisting of acridarsine, acridine, anthracene, arsinole, arsinoline, azepane, benzene, carbazole, carboline, chromene, cinnoline, furan, furazan, hexahydropyridazine, hexahydropyrimidine, imidazole, indane, indazole, indole, indolizine, isoarsindole, isobenzofuran, isochromene, isoindole, isophosphindole, isophosphinoline, isoquinoline, isorasinoline, isothiazole, isoxazole,  
20 morpholine, naphthalene, naphthyridine, oxazole, oxolane, perimidine, phenanthrene, phenanthridine, phenanthroline, phenarsazine, phenazine, phenomercurazine, phenomercurin, phenophosphazine, phenoselenazine, phenotellurazine, phenothiarsine, phenoxantimonin, phenoxaphosphine, phenoxarsine, phenoxaselenin, phenoxatellurin, phenothiazine, phenoxathiin, phenoxazine, phosphanthene,  
25 phosphindole, phosphinoline, phthalazine, piperazine, piperazine, piperidine, piperidine, pteridine, purine, pyran, pyrazine, pyrazole, pyridazine, pyridine, pyrimidine, pyrrolidine, pyrrolidine, pyrrolizine, quinazoline, quinoline, quinolizine, quinoxaline, selenanthrene, selenophene, tellurophene, tetrahydrofuran, tetrahydrothiophene, thianthrene, thiazole, thiolane, thiophene and xanthene.
- 30 6. The method of claim 1, wherein the potential catalysts comprise a bicyclo[x.y.z]alkane, where x, y, and z are each independently integers greater than or equal to zero.
7. The method of claim 1, wherein the potential catalysts comprise an asymmetric center.
8. The method of claim 1, wherein the library of potential catalysts comprises a catalyst  
35 that is not superimposable on its mirror image.

9. The method of claim 1, wherein the library comprises at least one hundred potential catalysts.
10. The method of claim 9, wherein the library comprises at least one thousand potential catalysts.
- 5 11. The method of claim 10, wherein the library comprises at least ten thousand potential catalysts.
12. The method of claim 1, wherein the potential catalysts comprise a saccharide or oligosaccharide.
13. The method of claim 12, wherein the saccharide, or oligosaccharide, consists of  
10 pentose sugars, hexose sugars, pentose azasugars, and/or hexose azasugars.
14. The method of any of claims 1-13, wherein the library is synthesized on a solid support.
15. The method of any of claims 1-13, wherein the library is synthesized in solution.
16. The method of claim 1, wherein a selected catalyst is used as the lead structure for a  
15 second library of potential catalysts; said second library of potential catalysts is screened to identify those members that catalyze the transformation of interest; at least one of the members of the second library being an improved catalyst for the transformation of interest relative to the catalyst from the first library.
17. The method of claim 16, wherein the described process is reiterated between one and  
20 ten additional times to provide at least one improved catalyst for the transformation of interest.
18. The method of claims 1, 16 or 17, wherein a selected catalyst catalyzes a transformation selected from the set comprising kinetic resolutions, regioselective reactions, chemoselective reactions, diastereoselective reactions, stereoselective  
25 reactions, functional group interconversions, hydrogenations, oxidations, reductions, resolutions of racemic mixtures, cycloadditions, sigmatropic rearrangements, electrocyclic reactions, ring-openings, carbonyl additions, carbonyl reductions, olefin additions, olefin reductions, imine additions, imine reductions, olefin epoxidations, olefin aziridinations, carbon-carbon bond formations, carbon-heteroatom bond formations, and heteroatom-heteroatom bond formations.  
30
19. The method of claim 1, 16, or 17, wherein the catalysts are selected based on the observation of a detectable event.
20. The method of claim 19, wherein the detectable event is a member of the set comprising the evolution of a gas, the emission of a photon, and the formation of a precipitate.

21. A library of potential catalysts, and the individual members thereof, having the following general structure:



wherein

5 the sphere represents a solid support;

Linker<sub>1</sub> and Linker<sub>2</sub> are independently selected from the group consisting of difunctional molecules with or without sidechains and/or stereocenters;

amino acid represents a natural or unnatural amino acid; and

10 the catalytic moiety is selected from the set comprising the catalytically-active portions of known catalysts.

22. The library and individual catalysts of claim 21, wherein

Linker<sub>1</sub> and Linker<sub>2</sub> are independently selected from the set comprising diamines, diols, amino alcohols, and diacids; and

15 the catalytic moiety is selected from the set comprising salenates, porphyrins, Schiff base-containing moieties, diketopiperazines, oligoamines, oligoalcohols, amino alcohols, oligopeptides, and oligonucleotides.

23. The library and individual catalysts of claim 22, wherein the catalytic moiety is mono-, di-, tri-, or tetra-dentate with respect to a substrate.

24. The library of claims 21, 22 or 23, wherein the library comprises at least one hundred  
20 potential catalysts.

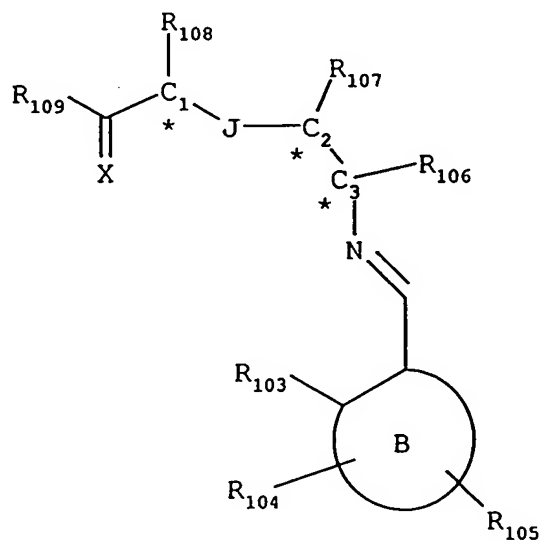
25. The library of claims 21, 22 or 23, wherein the library comprises at least one thousand potential catalysts.

26. The library of claims 21, 22 or 23, wherein the library comprises at least ten thousand potential catalysts.

25 27. The library and individual catalysts of claims 21, 22 or 23, wherein a selected catalyst is used as the lead structure for a second library of potential catalysts; said second library of potential catalysts is screened to identify those members that catalyze the transformation of interest; at least one of the members of the second library being an improved catalyst for the transformation of interest relative to the catalyst from the first library.

30 28. The library and individual catalysts of claim 27, wherein the described process is reiterated between one and ten additional times to provide at least one improved catalyst for the transformation of interest.

29. The method of claims 27 or 28, wherein a selected catalyst catalyzes a transformation selected from the set comprising kinetic resolutions, regioselective reactions, chemoselective reactions, diastereoselective reactions, stereoselective reactions, functional group interconversions, hydrogenations, oxidations, reductions, resolutions of racemic mixtures, cycloadditions, sigmatropic rearrangements, electrocyclic reactions, ring-openings, carbonyl additions, carbonyl reductions, olefin additions, olefin reductions, imine additions, imine reductions, olefin epoxidations, olefin aziridinations, carbon-carbon bond formations, carbon-heteroatom bond formations, and heteroatom-heteroatom bond formations.
30. The method of claims 27 or 28, wherein the catalysts are selected based on the observation of a detectable event.
31. The method of claim 30, wherein the detectable event is a member of the set comprising the evolution of a gas, the emission of a photon, and the formation of a precipitate.
32. A parallel, combinatorial method for the discovery and optimization of catalysts for a transformation from the set comprising the Strecker reaction, the aldol addition, the aldol condensation, the Michael addition, the Claisen rearrangement, the Cope rearrangement, the dihydroxylation of olefins, the epoxidation of olefins, the aziridination of olefins, the Darzen's condensation, the Diels-Alder reaction, the hetero-Diels-Alder reaction, the ene reaction, the hetero-ene reaction, the Wittig rearrangement, the Nazarov cyclization, the asymmetric addition of Grignard reagents to carbon-heteroatom  $\pi$ -bonds, the asymmetric addition of organolithium reagents to carbon-heteroatom  $\pi$ -bonds, the asymmetric Robinson annulation, and the Simmons-Smith reaction.
33. A catalyst represented by the following general structure:



25 wherein

B represents a monocyclic or polycyclic group;

C<sub>1</sub>, C<sub>2</sub> and C<sub>3</sub> each represent chiral carbon atoms;

X represents O, S or NH;

J represents a linker group including at least one functional group capable of acting  
5 as a hydrogen bond donor;

R<sub>103</sub> represents either a hydrogen bond donor, a Lewis basic group, or a group with both characteristics;

R<sub>104</sub> represents a sterically bulky, aliphatic or cycloaliphatic substituent of up to 20 carbons (preferably 2-10);

10 R<sub>105</sub> is absent, or represents one or more additional substituents of B selected from the group consisting of alkyl, alkenyl, alkynyl, acyl, thioacyl, alkylthio, imine, amide, phosphoryl, phosphonate, phosphine, carbonyl, carboxyl, carboxamide, anhydride, silyl, thioalkyl, alkylsulfonyl, arylsulfonyl, selenoalkyl, ketone, aldehyde, ester, heteroalkyl, amidine, acetal, ketal, aryl, heteroaryl, aziridine, carbamate, epoxide, hydroxamic acid, imide, oxime,  
15 sulfonamide, thioamide, thiocarbamate, urea, thiourea, or -(CH<sub>2</sub>)<sub>m</sub>-R<sub>80</sub>; and

R<sub>106</sub> and R<sub>107</sub> each independently represent alkyl, alkenyl, alkynyl, acyl, thioacyl, alkylthio, imine, amide, phosphoryl, phosphonate, phosphine, carbonyl, carboxyl, carboxamide, anhydride, silyl, thioalkyl, alkylsulfonyl, arylsulfonyl, selenoalkyl, ketone, aldehyde, ester, heteroalkyl, amidine, acetal, ketal, aryl, heteroaryl, aziridine, carbamate, epoxide,  
20 hydroxamic acid, imide, oxime, sulfonamide, thioamide, thiocarbamate, urea, thiourea, or -(CH<sub>2</sub>)<sub>m</sub>-R<sub>80</sub>, or

R<sub>106</sub> and R<sub>107</sub> taken together with C<sub>2</sub> and C<sub>3</sub> form a ring having from 4 to 8 atoms in the ring;

R<sub>108</sub> and R<sub>109</sub> each independently represent an alkyl, represent alkyl, alkenyl, alkynyl, acyl, thioacyl, alkylthio, imine, amide, phosphoryl, phosphonate, phosphine, carbonyl, carboxyl, carboxamide, anhydride, silyl, thioalkyl, alkylsulfonyl, arylsulfonyl, selenoalkyl, ketone, aldehyde, ester, heteroalkyl, amidine, acetal, ketal, aryl, heteroaryl, aziridine, carbamate, epoxide, hydroxamic acid, imide, oxime, sulfonamide, thioamide, thiocarbamate, urea, thiourea, or -(CH<sub>2</sub>)<sub>m</sub>-R<sub>80</sub>, with the proviso that R<sub>108</sub> and (C(X)R<sub>109</sub>) are not identical  
25 (this proviso is implied by the aforementioned chirality of C<sub>1</sub>);  
30

R<sub>80</sub> represents an unsubstituted or substituted aryl, a cycloalkyl, a cycloalkenyl, a heterocycle, or a polycycle; and

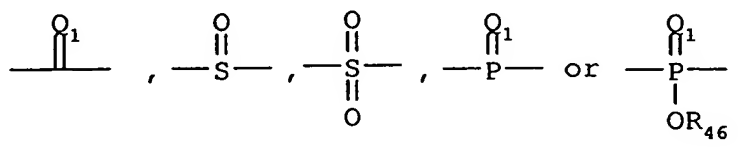
m is an integer in the range 0 to 8 inclusive.

34. A catalyst according to claim 33, wherein X is S or O.

35. A catalyst according to claim 33, wherein  $R_{103}$  is  $-NH_2$ ,  $-OH$ , or  $-SH$ , or a lower alkyl group substituted thereby.
36. A catalyst according to claim 33, wherein  $R_{104}$  is attached to B at a position both *ortho* to  $R_{103}$ , and *meta* to the imine substituent on B.
- 5 37. A catalyst according to claim 33, wherein  $R_{104}$  is a lower alkyl or alkoxy group.
38. A catalyst according to claim 33, wherein  $R_{106}$  and  $R_{107}$  are  $C_3$ - $C_8$  alkyl groups, or, together with  $C_2$  and  $C_3$  form a ring having from 4 to 8 atoms in the ring.
39. A catalyst according to claim 33, wherein

J is represented by  $-NH-Y-NH-$ ;

- 10 Y is selected from the group consisting of

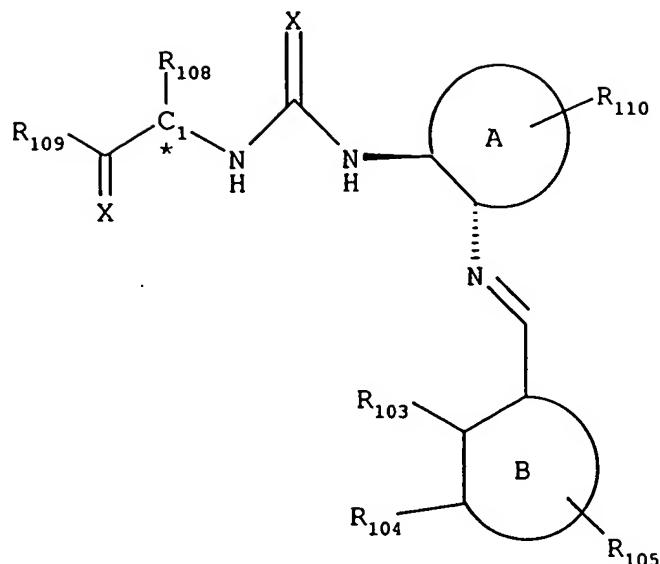


$Q_1$  represents S or O; and

$R_{46}$  represents hydrogen, a lower alkyl or an aryl.

- 15 40. A catalyst according to claim 39, wherein Y is  $-C(=Q_1)-$ ; and  $Q_1$  is O or S.

41. A catalyst according to claim 33, wherein  $R_{108}$  represents an alkyl, heteroalkyl, aryl or heteroaryl group.
42. A catalyst according to claim 33, 39, or 40, wherein  $R_{108}$  represents a side-chain of a naturally occurring  $\alpha$ -amino acid or analog thereof.
- 20 43. A catalyst according to claim 42, wherein  $R_{109}$  represents an amino group.
44. A catalyst represented by the following general structure:



wherein

A represents a monocyclic or polycyclic group;

B represents a monocyclic or polycyclic group;

5 C<sub>1</sub> represents a chiral carbon atom;

X represents O, S or NH;

R<sub>103</sub> represents either a hydrogen bond donor, a Lewis basic group, or a group with both characteristics;

10 R<sub>104</sub> represents a sterically bulky, aliphatic or cycloaliphatic substituent of up to 20 carbons;

R<sub>105</sub> is absent, or represents one or more additional substituents of B selected from the group consisting of alkyl, alkenyl, alkynyl, acyl, thioacyl, alkylthio, imine, amide, phosphoryl, phosphonate, phosphine, carbonyl, carboxyl, carboxamide, anhydride, silyl, thioalkyl, alkylsulfonyl, arylsulfonyl, selenoalkyl, ketone, aldehyde, ester, heteroalkyl, amidine, 15 acetal, ketal, aryl, heteroaryl, aziridine, carbamate, epoxide, hydroxamic acid, imide, oxime, sulfonamide, thioamide, thiocarbamate, urea, thiourea, or -(CH<sub>2</sub>)<sub>m</sub>-R<sub>80</sub>; and

R<sub>108</sub> and R<sub>109</sub> each independently represent an alkyl, represent alkyl, alkenyl, alkynyl, acyl, thioacyl, alkylthio, imine, amide, phosphoryl, phosphonate, phosphine, carbonyl, carboxyl, carboxamide, anhydride, silyl, thioalkyl, alkylsulfonyl, arylsulfonyl, selenoalkyl, 20 ketone, aldehyde, ester, heteroalkyl, amidine, acetal, ketal, aryl, heteroaryl, aziridine, carbamate, epoxide, hydroxamic acid, imide, oxime, sulfonamide, thioamide, thiocarbamate, urea, thiourea, or -(CH<sub>2</sub>)<sub>m</sub>-R<sub>80</sub>, with the proviso that R<sub>108</sub> and (C(X)R<sub>109</sub>) are not identical (this proviso is implied by the aforementioned chirality of C<sub>1</sub>);



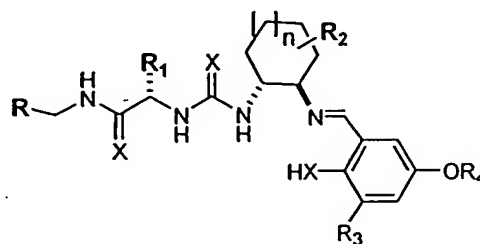
$R_{110}$  is absent, or represents one or more additional substituents of A selected from the group consisting of alkyl, alkenyl, alkynyl, acyl, thioacyl, alkylthio, imine, amide, phosphoryl, phosphonate, phosphine, carbonyl, carboxyl, carboxamide, anhydride, silyl, thioalkyl, alkylsulfonyl, arylsulfonyl, selenoalkyl, ketone, aldehyde, ester, heteroalkyl, amidine, 5 acetal, ketal, aryl, heteroaryl, aziridine, carbamate, epoxide, hydroxamic acid, imide, oxime, sulfonamide, thioamide, thiocarbamate, urea, thiourea, or  $-(CH_2)_m-R_{80}$ .

$R_{80}$  represents an unsubstituted or substituted aryl, a cycloalkyl, a cycloalkenyl, a heterocycle, or a polycycle; and

$m$  is an integer in the range 0 to 8 inclusive.

10 45. A catalyst according to claim 44, wherein A is a cycloalkyl having 5, 6 or 7 carbons in the ring structure.

46. A catalyst represented by the following general formula:



wherein

15 X represents, independently for each occurrence, O, S, or NR;

$R$ ,  $R_1$ ,  $R_2$ , and  $R_3$  represent, independently for each occurrence, H, alkyl, aryl, heteroalkyl, or heteroaryl;

$R_4$  represents H, alkyl, heteroalkyl, aryl, heteroaryl, formyl, or acyl;

$R_2$  is absent or occurs no more than 4 times; and

20  $n$  is an integer selected from the range 0 to 2 inclusive.

47. A catalyst according to claim 46, wherein

X represents, independently for each occurrence, O or S;

$R$ ,  $R_1$ ,  $R_2$ , and  $R_3$  represent, independently for each occurrence, H, alkyl, aryl, heteroalkyl, or heteroaryl;

25  $R_4$  represents alkyl, heteroalkyl, aryl, or heteroaryl;

$R_2$  is absent; and

$n$  is an integer selected from the range 0 to 2 inclusive.

48. A catalyst according to claim 47, wherein

X represents, independently for each occurrence, O or S;

R, R<sub>1</sub>, R<sub>2</sub>, and R<sub>3</sub> represent, independently for each occurrence, H, alkyl, aryl, heteroalkyl, or heteroaryl;

R<sub>4</sub> represents formyl or acyl;

5 R<sub>2</sub> is absent; and

n is an integer selected from the range 0 to 2 inclusive.

49. A catalyst according to claim 33, 44, or 46, wherein said catalyst catalyzes an enantioselective or diastereoselective transformation that produces a product with an enantiomeric or diastereomeric excess, respectively, of at least 75%.

10 50. A catalyst according to claim 33, 44, or 46, wherein said catalyst catalyzes an enantioselective or diastereoselective transformation that produces a product with an enantiomeric or diastereomeric excess, respectively, of at least 80%.

15 51. A catalyst according to claim 33, 44, or 46, wherein said catalyst catalyzes an enantioselective or diastereoselective transformation that produces a product with an enantiomeric or diastereomeric excess, respectively, of at least 85%.

52. A catalyst according to claim 33, 44, or 46, wherein said catalyst catalyzes an enantioselective or diastereoselective transformation that produces a product with an enantiomeric or diastereomeric excess, respectively, of at least 90%.

20 53. A catalyst according to claim 33, 44, or 46, wherein said catalyst catalyzes an enantioselective or diastereoselective transformation that produces a product with an enantiomeric or diastereomeric excess, respectively, of at least 95%.

54. A catalyst according to claim 33, 44, or 46, wherein said catalyst catalyzes an enantioselective or diastereoselective transformation that produces a product with an enantiomeric or diastereomeric excess, respectively, of at least 98%.

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